CHEMICAL & BIOLOGICAL WARFARE AGENTS

NAVY ENVIRONMENTAL & PREVENTIVE MEDICINE UNIT NO. 5

Early Warfare

1,000 BC Patagonian Indian

300 BC Saxon

1139 AD

Early Biological Warfare

- Filth, cadavers, animal carcasses and contagion to contaminate water sources
  - 400 B.C. Scythian archers: arrows dipped in blood, manure, decomposing bodies.
  - 1346: plague at Kaffa (now Feodossia, Ukraine) started by Tartar soldiers throwing bodies of fellow soldiers who succumbed to the plague over the wall into the city. (May have started the Black Death pandemic in Europe.)

Early Biological Warfare

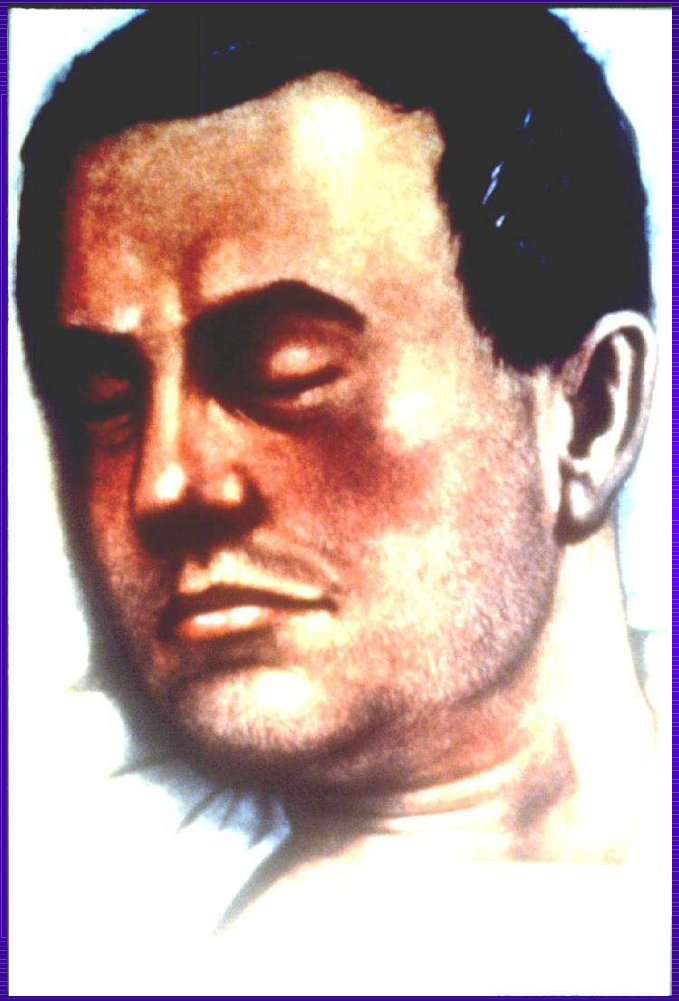
1767

French and Indian Wars: Sir Jeffrey Amherst orders Smallpox - infected blankets given to Indians defending, Fort Carillon

1st Gas Attack: 22 April 1915

Ypres, Belgium

WWI Chlorine Gas



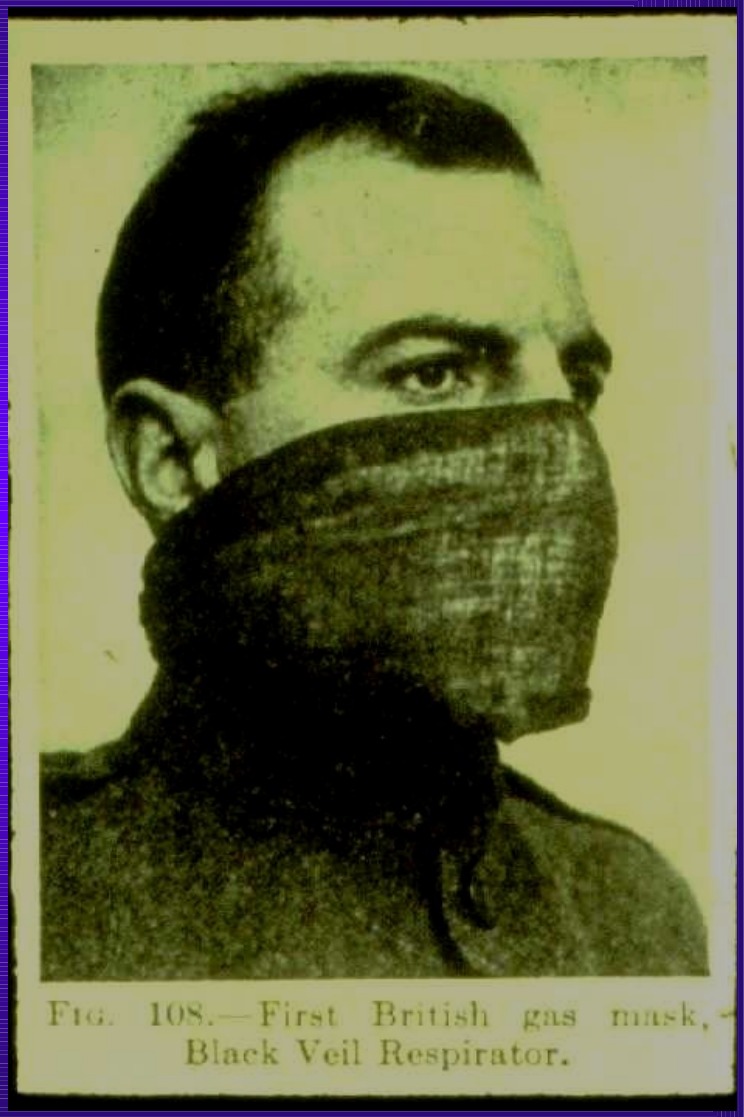


Fig. 108.—First British gas mask, Black Veil Respirator.

Potpourri of Protective Masks

Chem/Bio Defense Command Historical Research and Res[illegible] Team

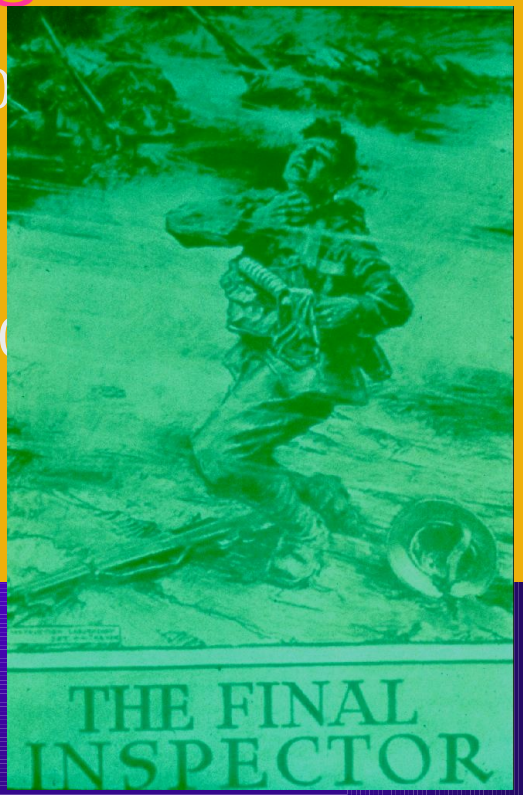
WWI Casualties: Britain

DATES	GAS	CASUALTIES
Aug 1916-Jul 1917	Lung Irritants	20,000*
Aug 1917-Nov 1918	Mustard	180,000*

* Not all casualties were deat

WWI Casualties: American Expeditionary

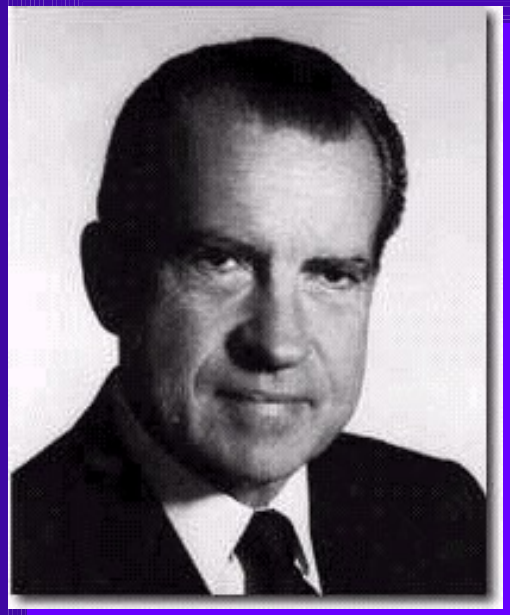
GAS	CASUALTIES
UNKNOWN	33,50
CHLORINE	1,800
PHOSGENE	6,8(
MUSTARD	27,700 # *



Not all casualties were deaths

* U. S. Entered the war in 1917 after Mustard was introduced

U. S. Terminates Biowarfare Program



1969

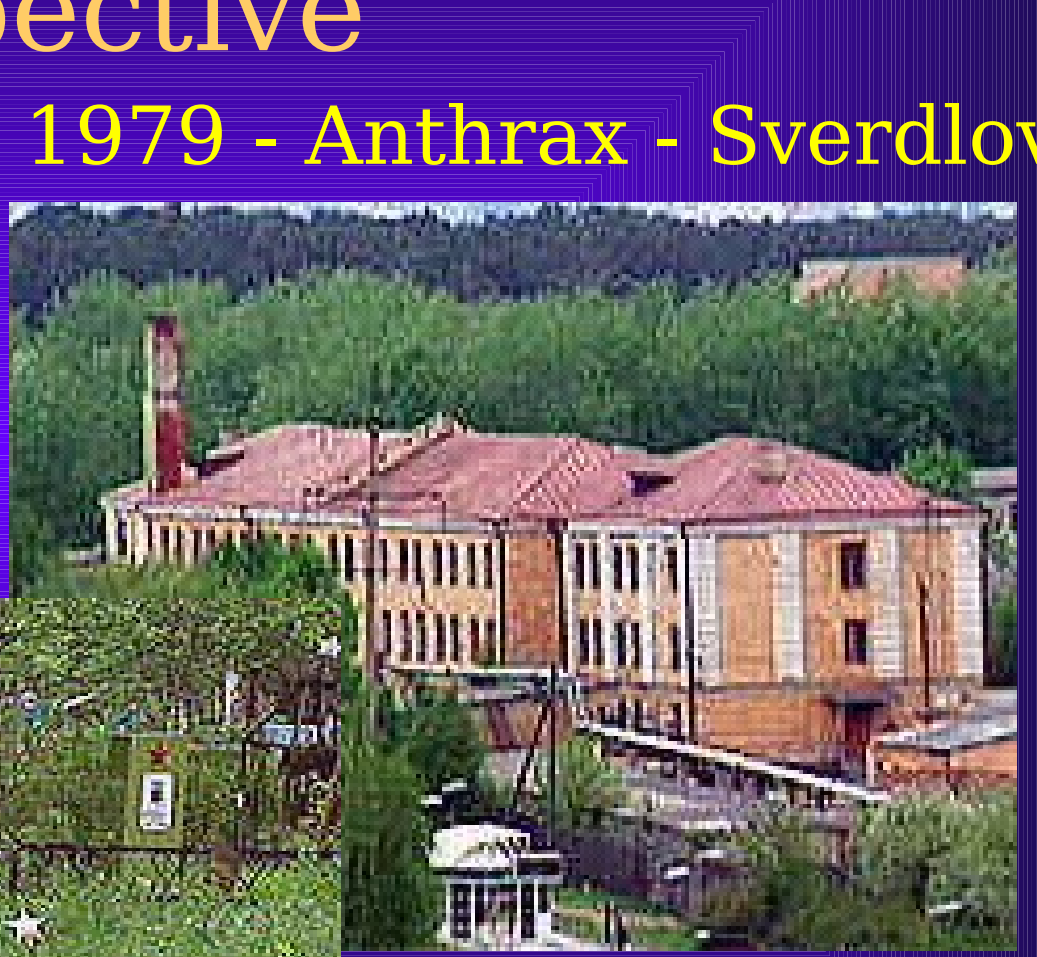
After a successful year of intensive testing of U.S. offensive biological munitions in the Pacific Ocean, President Nixon terminates the U. S. Biological warfare program and orders all stockpiled weapons

Vietnam - Agent orange

Iran-Iraq War - Mustard

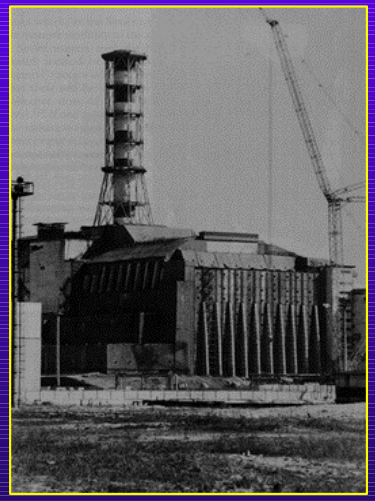
Events Which Changed Our Perspective

1979 - Anthrax - Sverdlov



Compound 19

Events Which Changed Our Perspective

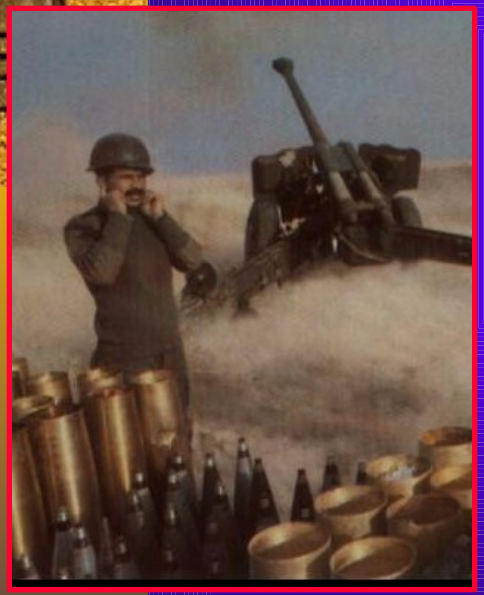


Reactor Accident Chernobyl April 26, 1986

31 Deaths
237 Acute Radiation

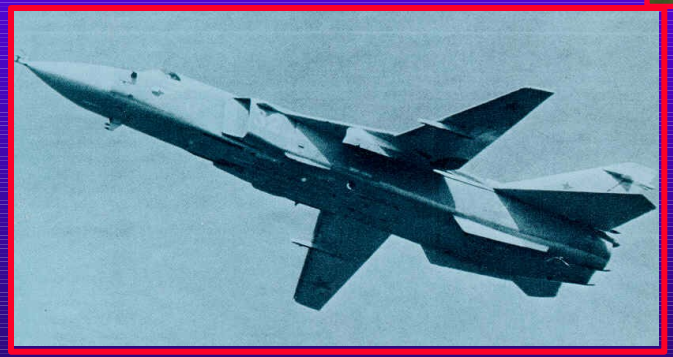
Delivery Methods

- Conventional



Field artillery

300-mm Smerch



Air-delivery

Mobile SCUD

Delivery Methods

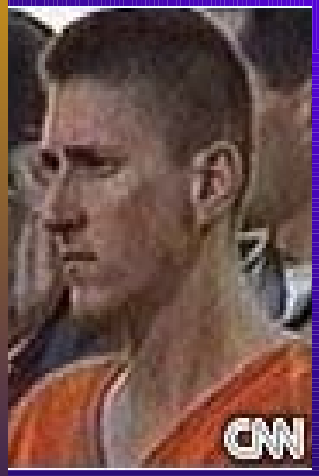
- Unconventional
  - Portable generators
  - Suitcases
  - Canisters / jars

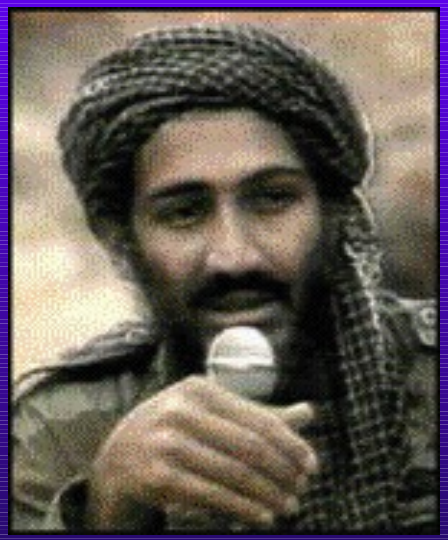
**** Most effective when delivered in aerosol form in 1-5 Micron sizes just before sunrise, at dusk or at night in hot, humid weather conditions (Bio or Chem)**

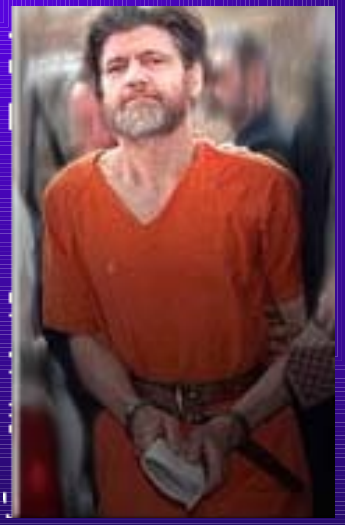
Pesticide sprayer

Terrorism:

Terrorism is the unlawful use of force or violence aga
or property to intimidate or coerce a government, the
population, or any segment thereof, in furtherance o
or social objectives. ---*FBI Definition*



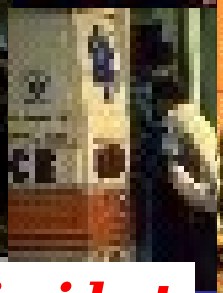




World Trade Center, NYC

February 26, 1993

6 civilians killed Over 1,000 injured



Sodium cyanide was used in the incident but failed to vaporize as planned

Tokyo: Sarin Nerve Agent Attack

March 20, 1995

- **Nerve agent Sarin released in Tokyo subway system**
- **12 killed, 5,500 sought medical treatment**

Murrah Federal Building, Oklahoma City

April 19, 1995, 9:03 a.m.,

168 Deaths, 518 Injured

Kobar Towers, Dhahran

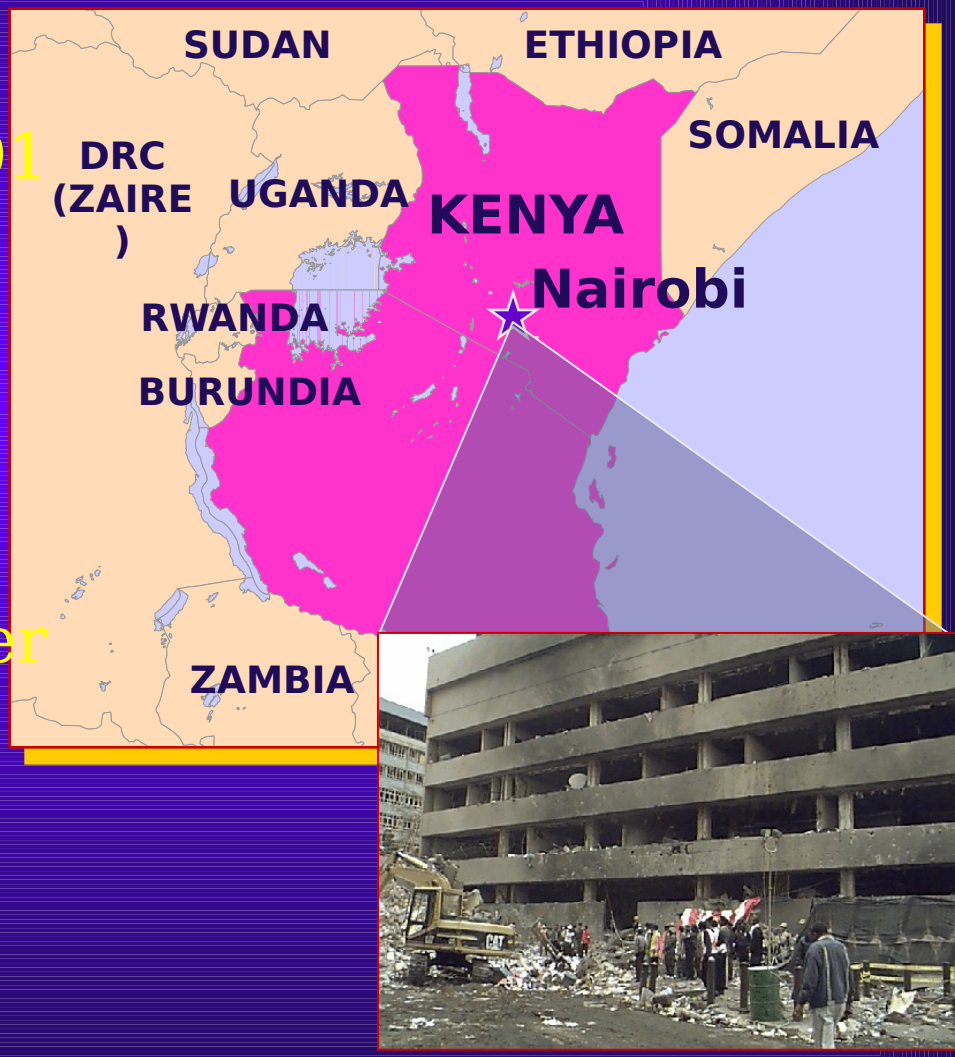
25 June 1996

19 KIA
500+ WIA

Nairobi, Kenya

Time of Attack: 0335 EST
Total confirmed killed -- 291
12 AMCIT, 32 FSN, 247 Kenyans
Truck bomb detonated in driveway behind embassy; Crater 20 x 30 x 10 feet deep
Attacker intent was to enter embassy underground parking

Preliminary assessment: large improvised bomb, possibly 1,000 lbs of HE



Dar es Salaam, Tanzania

Time of attack: 0340 EST

Total confirmed killed -- 10

Car bomb detonated 10 feet from main gate - crater 8 feet x 8 feet x 4 feet deep

Bomb damage suggests 400 - 600 lbs of HE boosted with hydrogen

Map of Domestic Preparedness Programs

NERVE AGENTS

NERVE AGENTS

- GA (Tabun)
- GB (Sarin)
- GD (Soman)
- GF
- VX

NERVE AGENTS PHYSICAL PROPERTIES

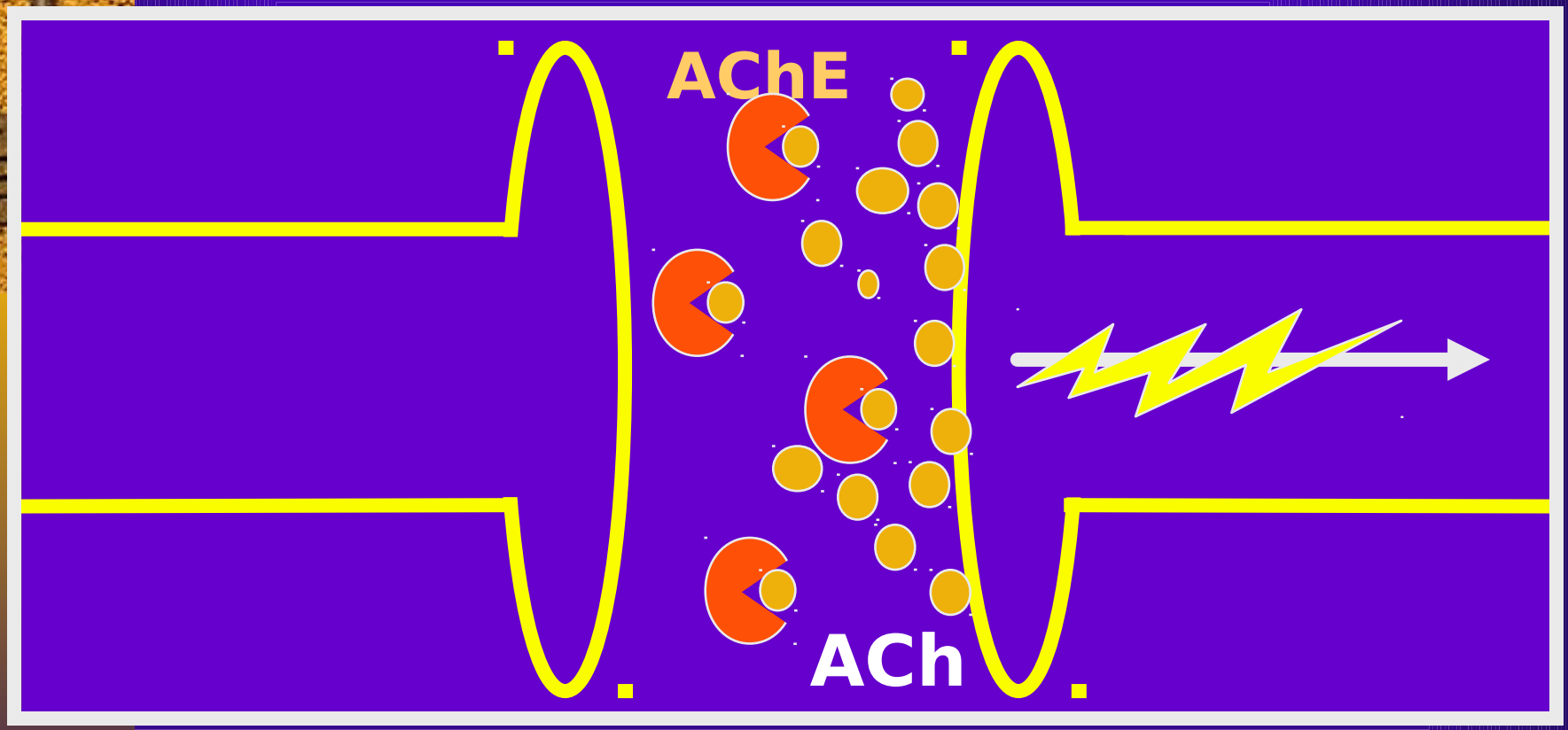
- Clear, colorless liquids (when fresh), not “nerve gas”
- Tasteless, most are odorless
- Freeze/melt <0º C
- Boil >150º C
- Volatility GB>GD>GA>GF>VX
- Penetrate skin, clothing

LD50 of VX: 10mg/70kg

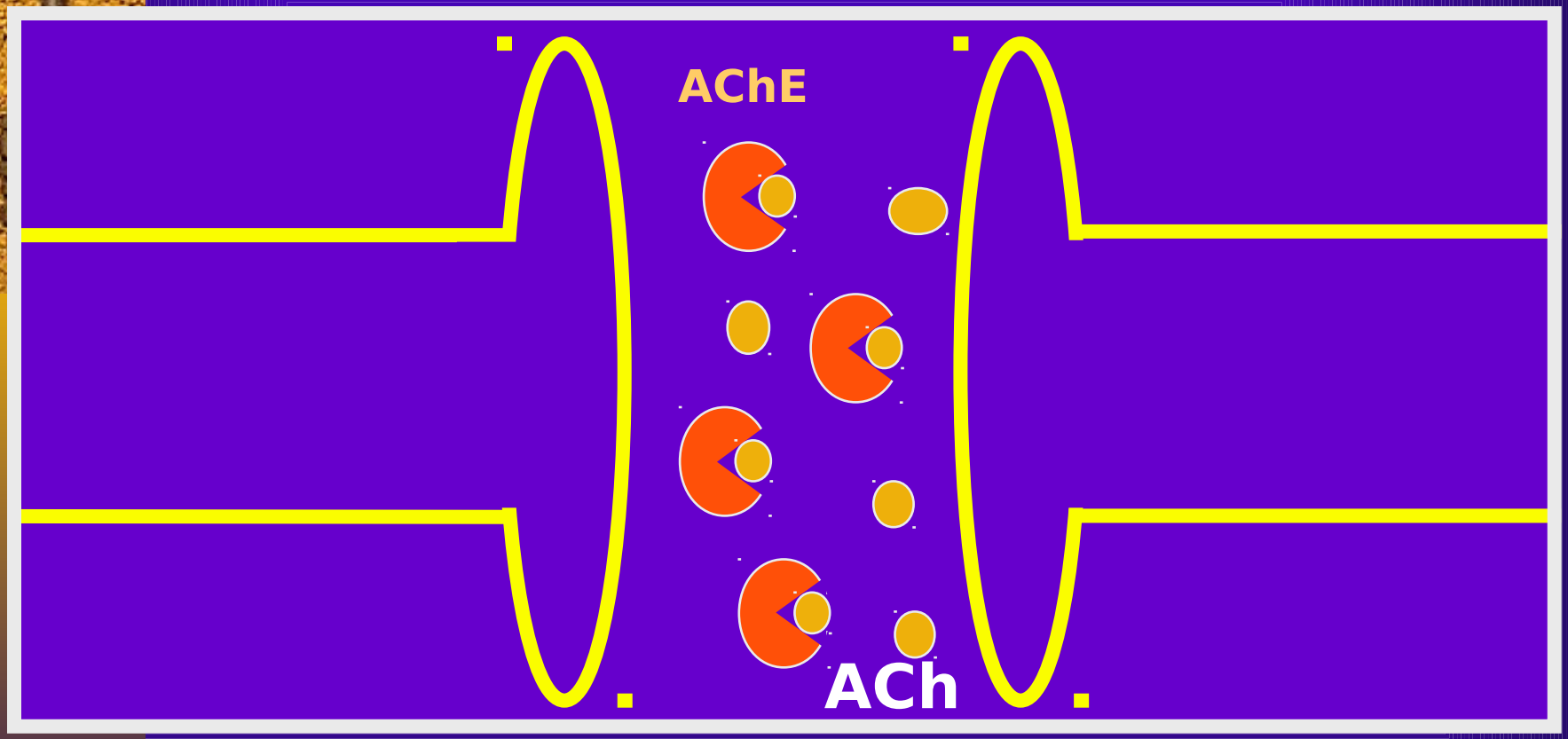
NORMAL PHYSIOLOGY

- Electrical impulse goes down nerve
- Impulse causes release of neurotransmitter, acetylcholine
- ACh stimulates receptor site on organ
- Causes organ to act
- ACh is destroyed by AChE
- No more organ activity

IMPULSE TERMINATION: THE ROLE OF AChE



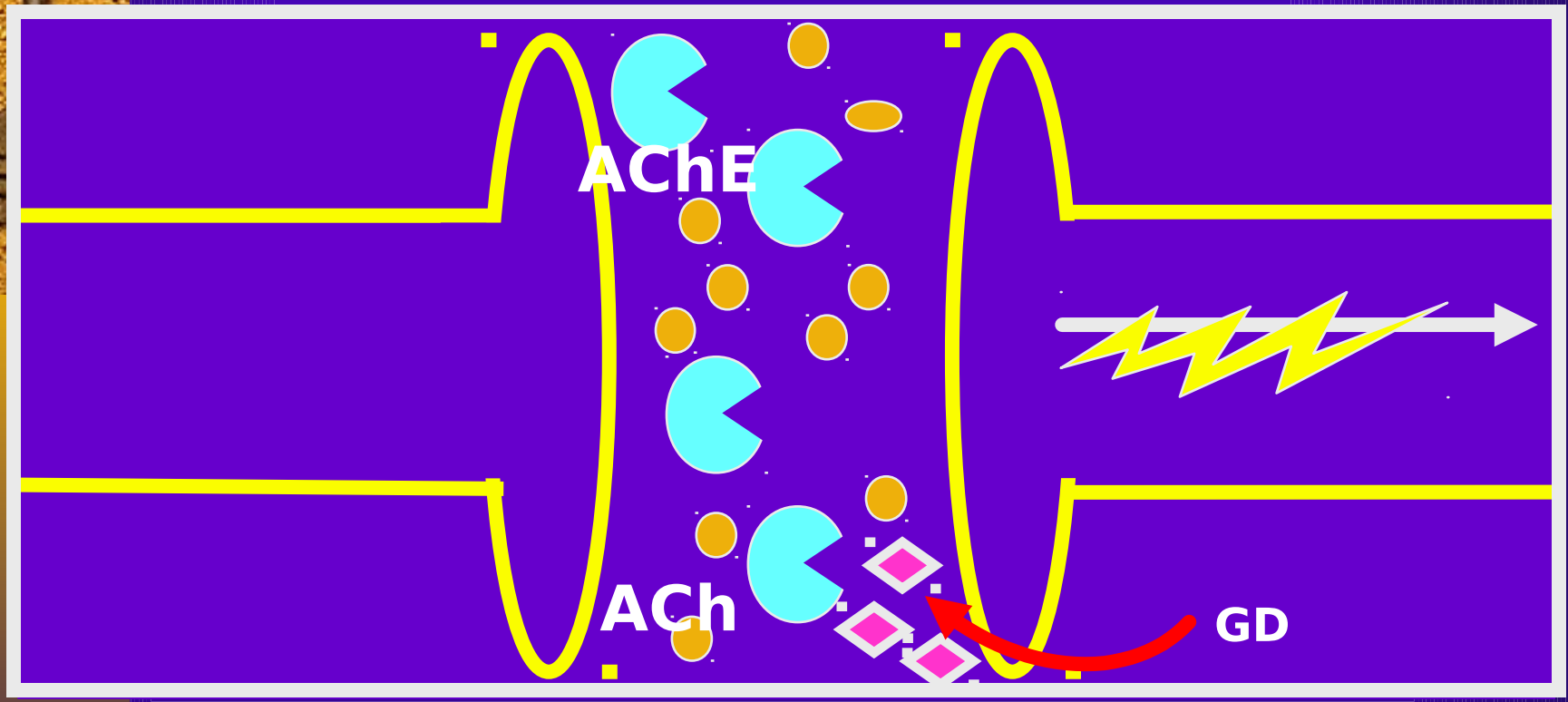
IMPULSE TERMINATION: THE ROLE OF AChE



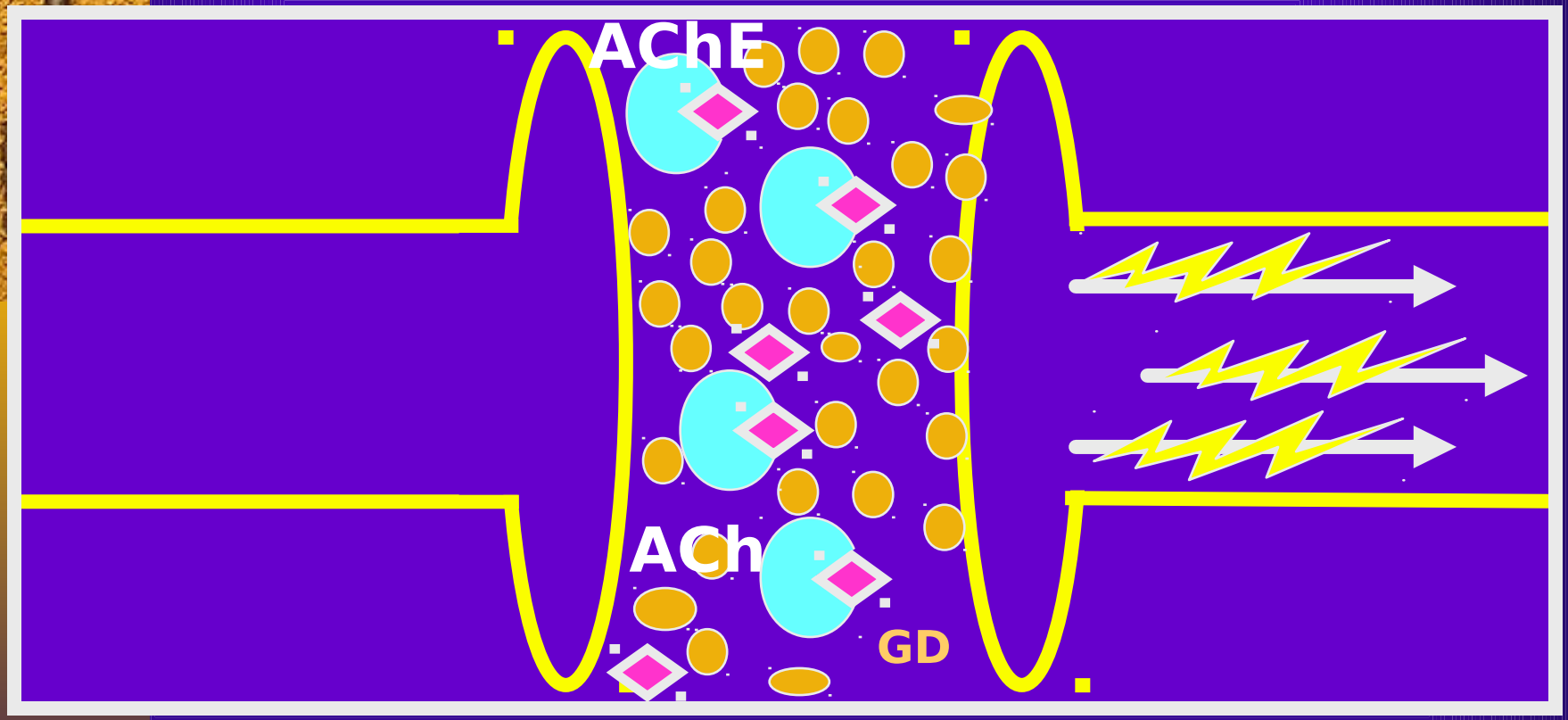
PHYSIOLOGY: NERVE AGENT

- Enzyme (AChE) is inhibited
- Does not destroy ACh
- Excess ACh continues to stimulate organ
- Organ overstimulation ⇒ symptoms

EXPOSURE TO NERVE AGENT



EXPOSURE TO NERVE AGENT



NERVE AGENT SITES OF ACTION

- Two types of nerve synapses are affected by acetylcholine excess:
  1. Muscarinic
     - Smooth Muscles
     - Glands
     - Vagus Nerve
  2. Nicotinic
     - Skeletal Muscles
     - Pre-Ganglionic Nerves

NICOTINIC EFFECTS

- Skeletal muscles
  - Fasciculations, twitching, fatigue, flaccid paralysis
- Pre-ganglionic (autonomic)
  - Tachycardia, hypertension

NERVE AGENT SYMPTOMS

- Minor CNS effects
  - Slowness in thinking and decision making
  - Sleep disturbances
  - Poor concentration
  - Emotional problems
  - Other minor problems

NERVE AGENT SYMPTOMS

- MINOR CNS EFFECTS
  - May last for 3 to 6 weeks
  - May follow any exposure
  - Not always present
  - Very slight, subtle

NERVE AGENT SYMPTOMS

VAPOR

- Minor CNS effects
  - Slow thinking/decision making/poor concentration
  - Sleep disturb
  - Emotional problems

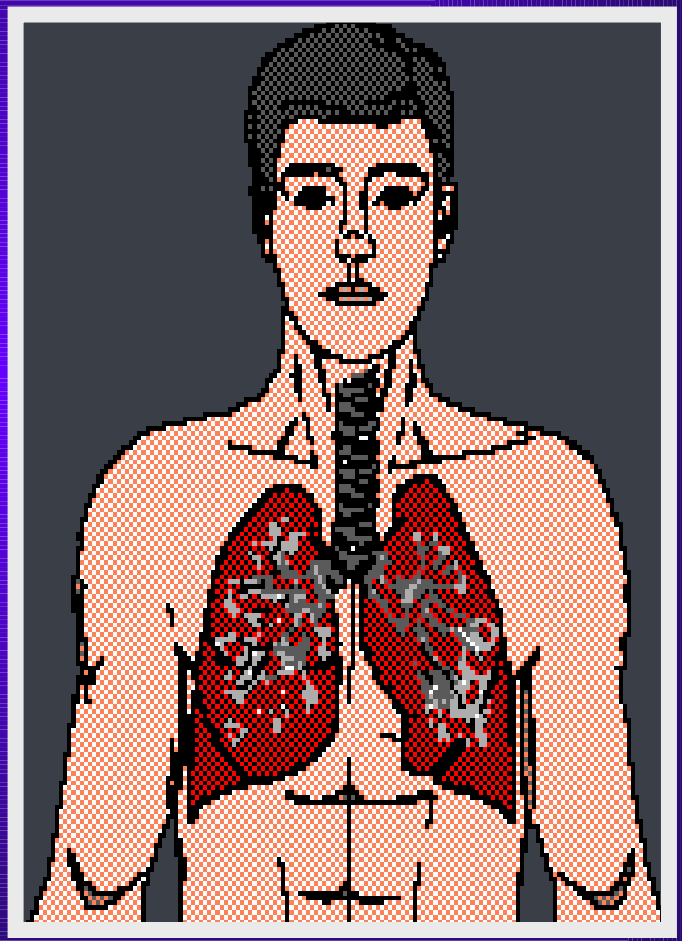
- Eyes: Miosis; injection; dim, blurred vision; pain; maybe nausea, vomiting

VAPOR - NOSE and MOUTH

- Runny nose
  - Worse than cold or l
  - Leaking faucet
- Mouth
  - Excessive saliva
  - May run out corners

VAPOR - RESPIRATORY TRACT

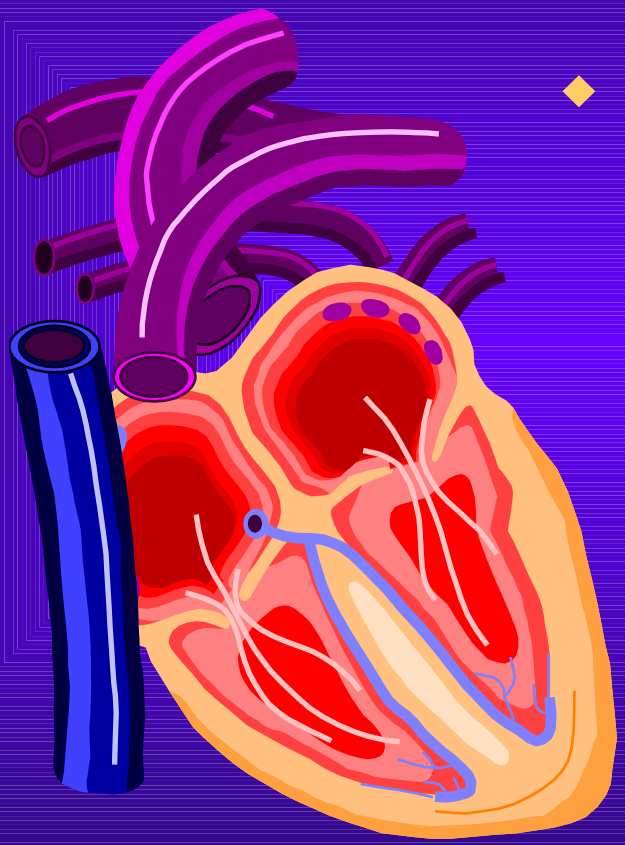
- Small exposure
  - Tight chest
- Moderate exposure
  - Dyspnea
  - Gasping, irregular breathing
  - Compounded by excessive secretions



VAPOR - GASTROINTESTINAL

- Exposure to a large but non-lethal concentration may cause:
  - Nausea, vomiting
  - Pain in abdomen
  - Diarrhea, involuntary defecation or urination

VAPOR - CARDIAC



- Heart rate
  - Increase or decrease
  - Blood pressure - increase
  - NOT AN INDICATOR FOR CARE

VAPOR: LARGE EXPOSURE

- Previously listed effects *pl*
  - Loss of consciousness
  - Seizures
  - Apnea
  - Flaccid paralysis
  - Death

VAPOR

- Onset of effects: seconds to minutes
- After removal from vapor
  - Effects do not worsen
  - May improve
- No late-onset effects

LIQUID ON SKIN

- Small droplet: local effects
  - Sweating, fasciculations
- Medium droplet: systemic effects
  - GI
- Large droplet: CNS
  - Loss of consciousness, seizures, apnea, flaccid paralysis, death

LIQUID ON SKIN

- Onset of effects
  - Small, medium drop
    - As long as 18 hours
  - Large, lethal drop
    - Usually <30 minutes

LIQUID ON SKIN

- Onset time and penetration is dependent on:
  - Skin site (head/neck>extremities>torso)
  - Temperature
  - Moisture
  - Lean vs Obese

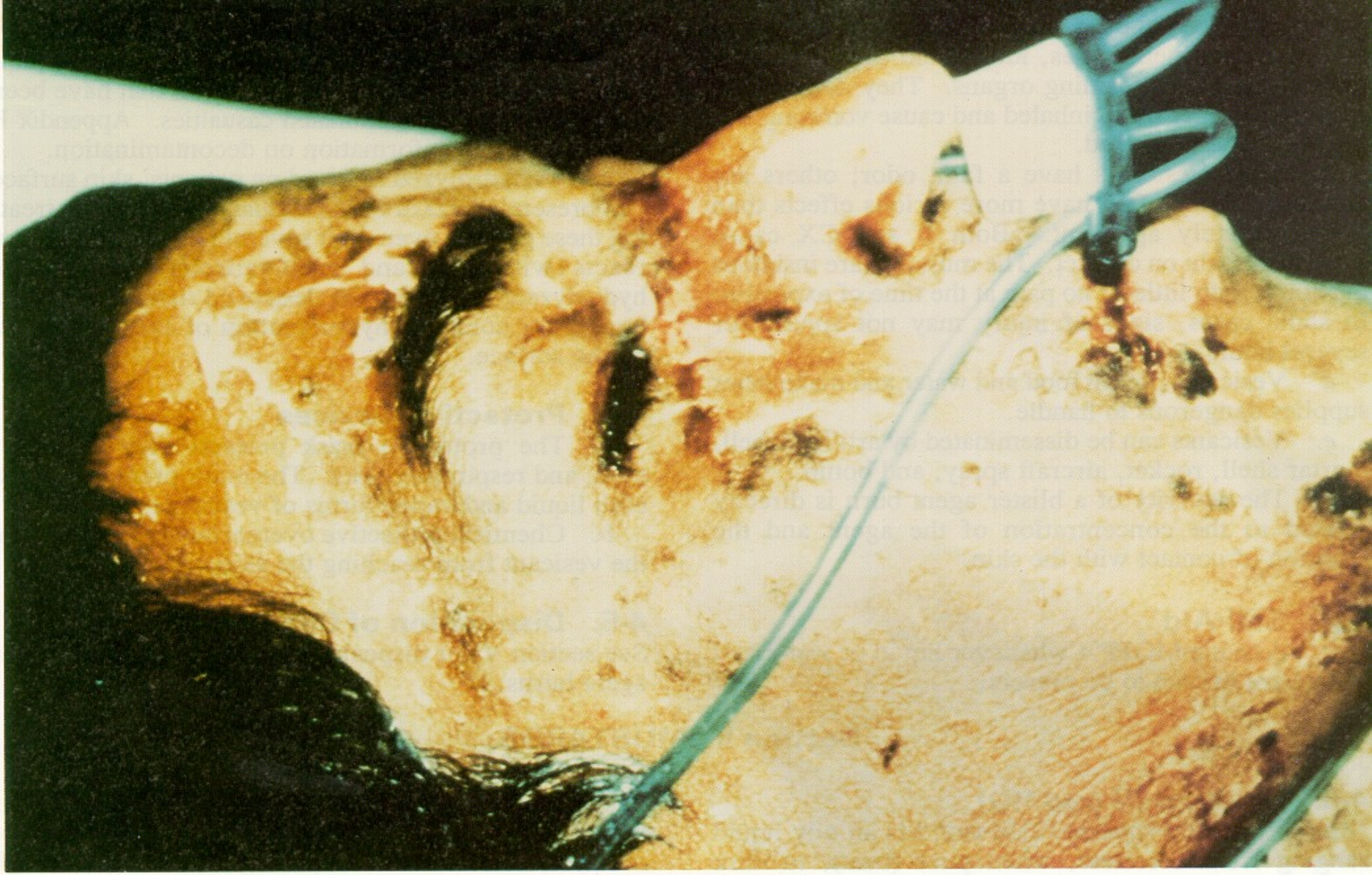
MIOSIS

- Almost always after vapor
- After liquid on skin:
  - Small: no
  - Moderate: maybe
  - Severe: yes

MUSTARD

MILITARY VESICANTS

- Mustards
  - Sulfur (agent)
  - Nitrogen (chemotherapy)
- Lewisite
- Phosgene oxime



SOURCE: Photograph provided by Iranian News Agency.

Figure 4-1. Casualty with mustard burn of the face and eyes.

SULFUR MUSTARD

2-CH_2CH_2Cl

/

S

\

$CH_2 - CH_2 - Cl$

Thiodiglycol

$CH_2 - CH_2 - OH$

/

S

\

$CH_2 - CH_2 - OH$

MUSTARD

- Oily liquid
- Light yellow to brown
- Vapor heavier than air
- Liquid heavier than water
- Low volatility; persistent
- Freezes/melts at 58°F

MUSTARD PENETRATION

- Through skin, surfaces in minutes
- 80% on skin evaporates
- Part is “fixed” in skin, rest circulates

MUSTARD

- Quickly cyclizes in tissue
- Alklates cell components, that is, DNA
- DNA damage, cell death

MUSTARD TOXICITY

Vapor (mg-min/m^3)

Eye	10 to 50
Airways	100 to 500
Skin	200 to 1,000
Death	1,500

MUSTARD TOXICITY (CONT'D)

Liquid

Blister	10 µg
Death	100 mg/kg
	7 gm/70 kg

MUSTARD: ONSET

- Cellular interaction: 1 to 2 minutes
- Clinical effects: 2 to 48 hours
  Usually 4 to 8 hours

SOURCE: Photograph provided by Iranian News Agency.

Figure 4-9. Casualty with severe blisters on the back.

MUSTARD: SKIN

- Erythema
- Small vesicles; later coalesce
- Blisters/bulla
- Possible coagulation necrosis with liquid

MUSTARD: EYE

- Mild conjunctivitis
- Moderate/severe conjunctivitis, lid inflammation and edema, blepharospasm, corneal roughening
- Corneal opacification, ulceration, and/or perforation
- Well over 90% have only mild to moderate conjunctivitis
- Under 1% permanent damage to cornea

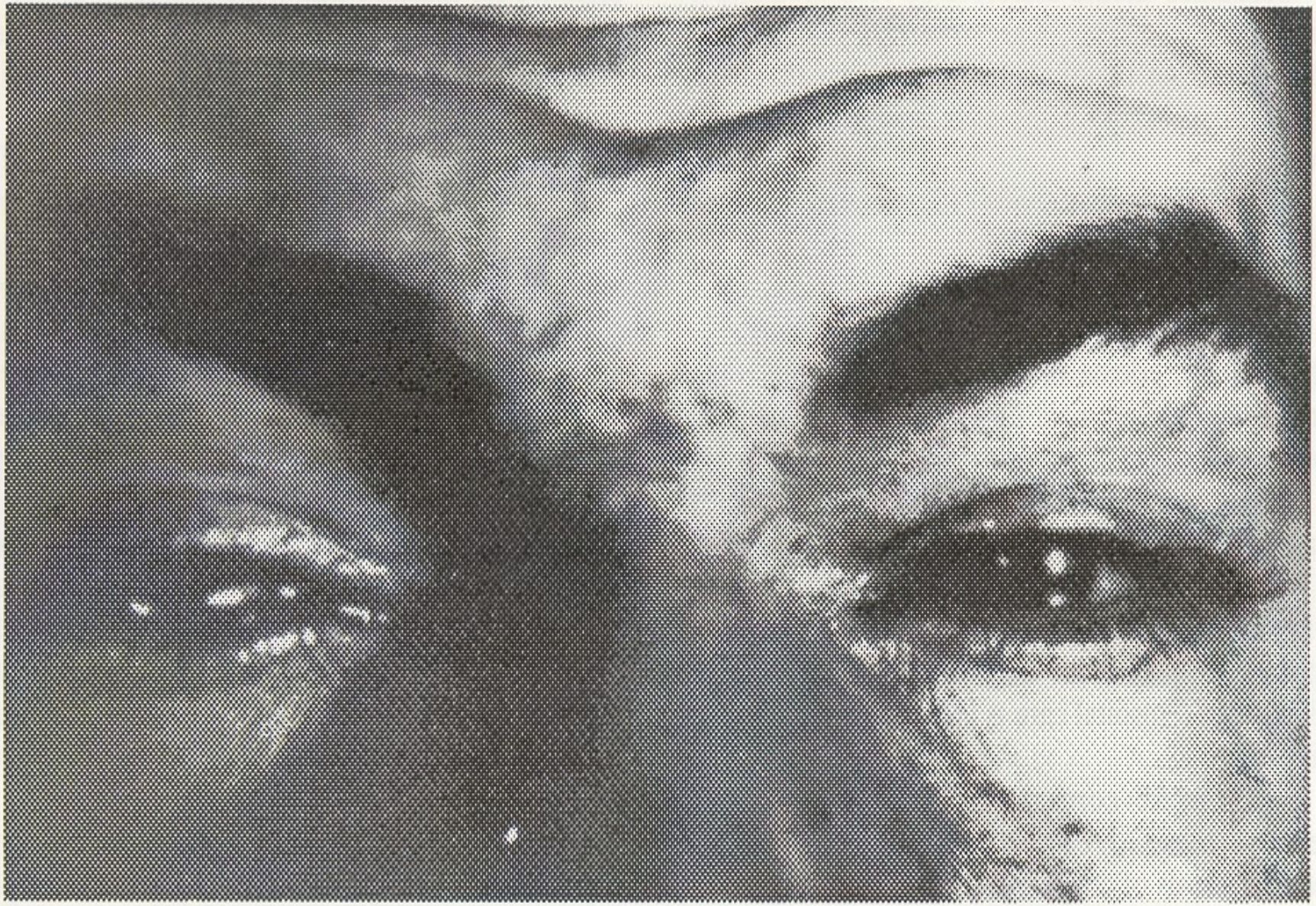


Figure 4-3. Casualty showing eye effects of mustard vapor.

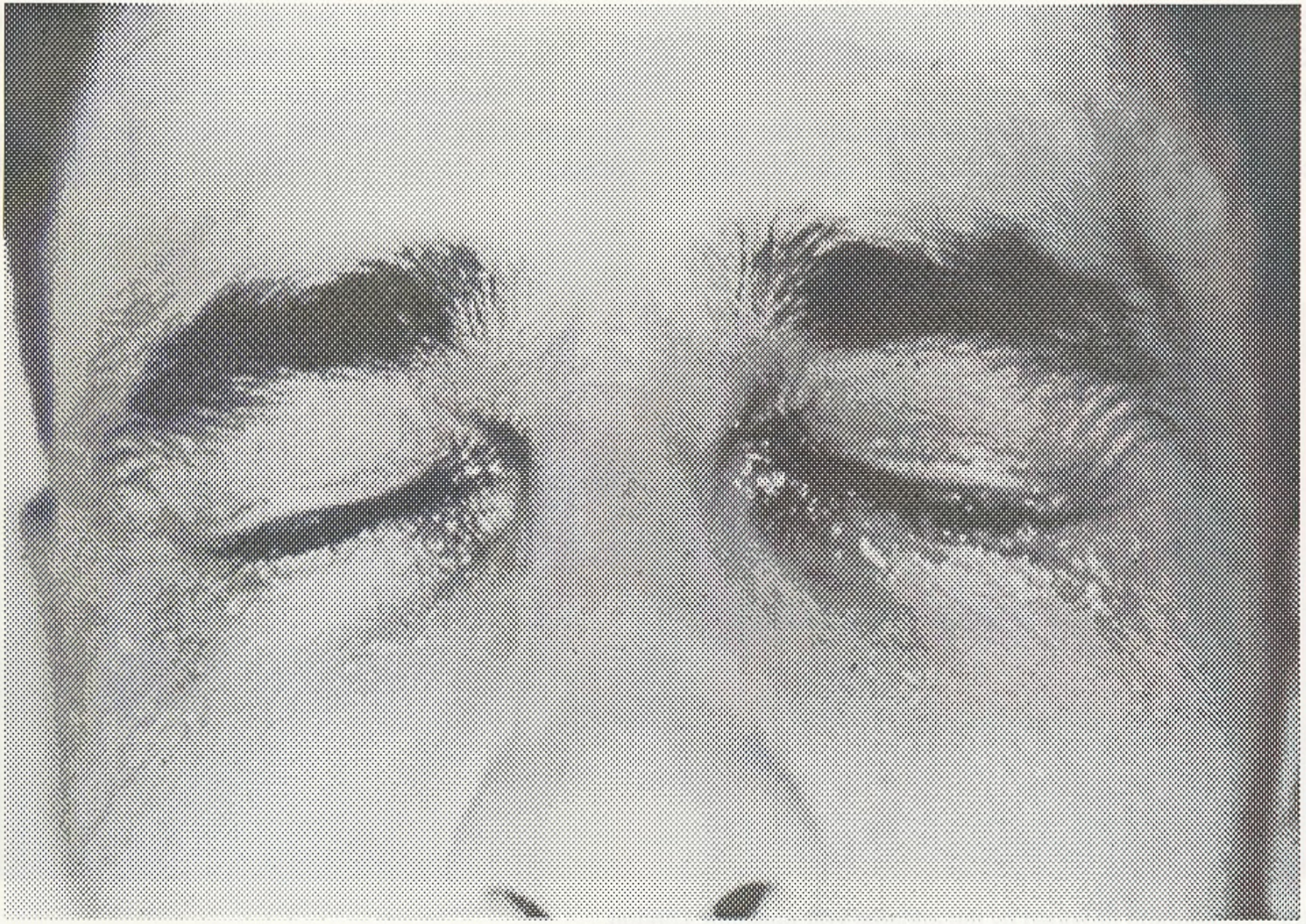
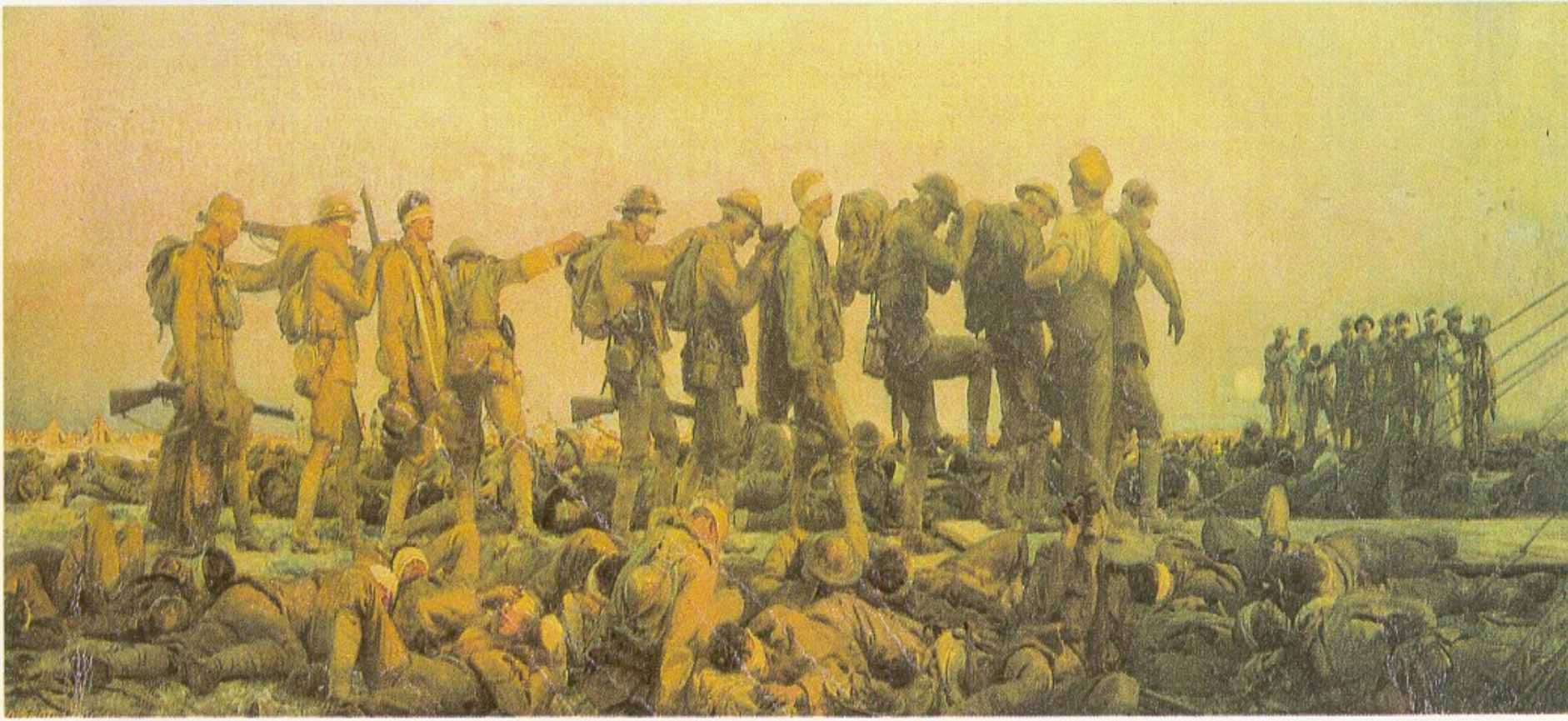


Figure 4-4. Casualty showing effects of mustard conjunctivitis.



SOURCE: Photograph provided by the Imperial War Museum, London.

Figure 4-2. Sick call line of service members suffering from mustard eye irritation.

MUSTARD: AIRWAYS

- Nasopharynx: Nose, sinuses, pharynx (epistaxis, sore throat, hacking cough)
- Upper central: Larynx (hoarseness)
- Lower central/ peripheral: Bronchioles (dyspnea, productive cough)

MUSTARD: AIRWAYS

- Mild exposure/start of more severe: Upper
- Moderate exposure: Mid
- Severe: Lower
- Pulmonary edema rare; with severe exposure
- Pseudomembranes

MUSTARD: DEATH

- May be pulmonary:
  - Damaged airways
  - Infection
  - Depressed immune system
  - Sepsis

MUSTARD: TIME

- Early symptom onset = severe injury
- Airway onset <4 to 6 hours = often fatal

DIFFERENTIAL DIAGNOSIS

- Isolated cases: plant, animal, other types of chemicals
- Many cases, on battlefield:
  - Mustard - no immediate effects
  - Lewisite, phosgene oxime: Immediate pain

BIOLOGICAL AGENTS

Biological Warfare Characteristics

- Dispersed by aerosols and not visible
- Simple technology for delivery readily availa (airplane, artillery, boat, car)
- Difficult to detect and mass casualties days may be first signal
- Use in military combat zone as well as in ter or assassination possible

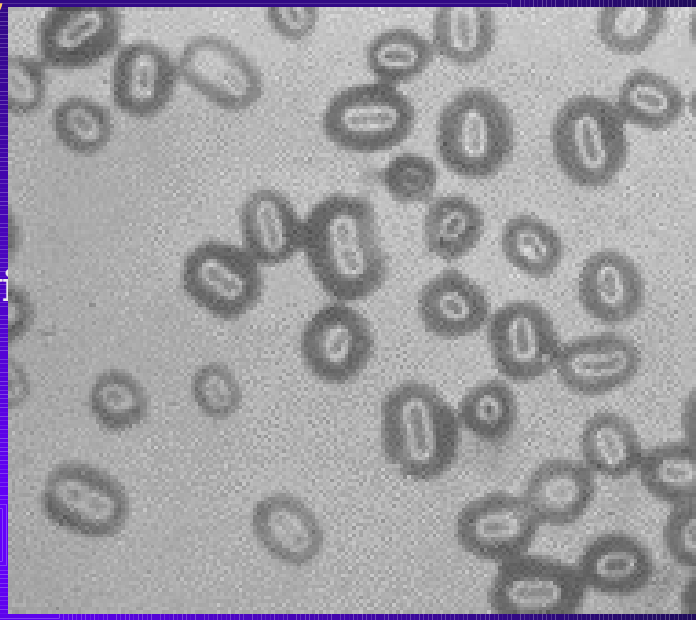
TI-AUH

*Hypothetical Dissemination by Airplane of 50 kg of Agent Along a 2 km line Upwind of a Population Center of 500,000**

Agent	Downwind Reach (km)	Dead	Incapacita
Rift Valley Fever	1	400	35,000
Tick-Borne Enceph	1	9,500	35,000
Typhus	5	19,000	85,000
Brucellosis	10	500	100,000
Q Fever	>20	150	125,000
Tularemia	>20	30,000	125,000
Anthrax	>>20	95,000	125,000

* Health Aspects of Chemical and Biological Weapons, WHO, 1

Plague



- **Etiologic agent:** ***Yersinia pestis***
- **Transmission:** **100-500 organisms**
  - **-Natural: Rodent to human via flea**
    Human to Human vi
    aerosol
  - **-BW: Aerosol, water, food, fomites**
- **Incubation:** **2-6 days**
- **Clinical Presentation:** **bubonic, septicemic and pneumonic**
- **BW Presentation:** **Acute pneumonia , sepsis**
- **Fatality:** **Pneumonic/Septicemic plague > 95%**
- **Treatment:** **Streptomycin, tetracycline**
- **Vaccine:** **Ineffective against pneumonic plague**

PLAGUE VECTORS

Xenopsylla cheopsis

Pulex irritans

Diamanus montanus

RODENT RESERVOIR

R. norvegicus

and many other rodents

Septicemic Plague

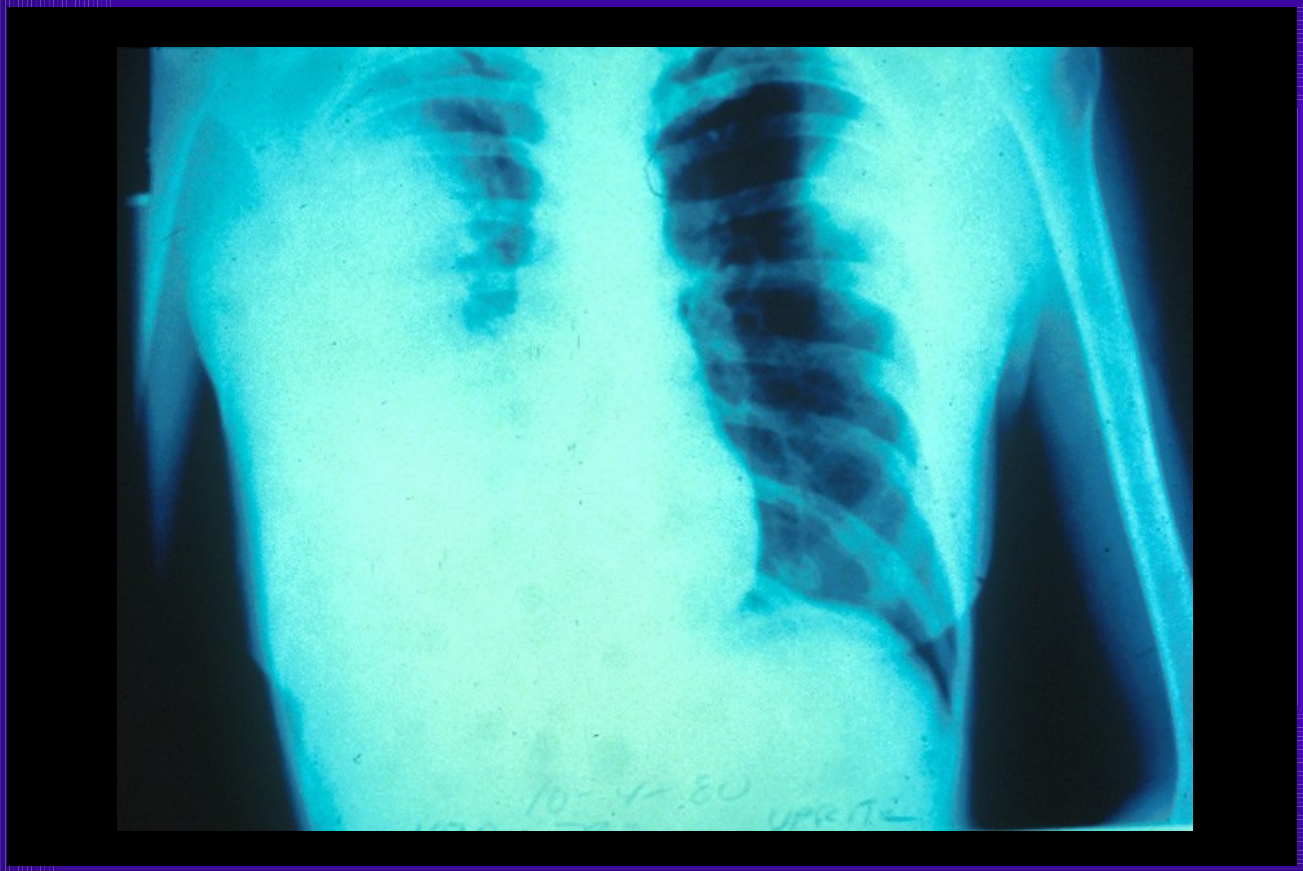
TMM, Medical Aspects of Chem & Bio Warfare

Bubonic Plague

Femoral and axillary buboes

TMM, Medical Aspects of Chem & Bio Warfare

PNEUMONIC PLAGUE



Right-middle and lower lobe involveme

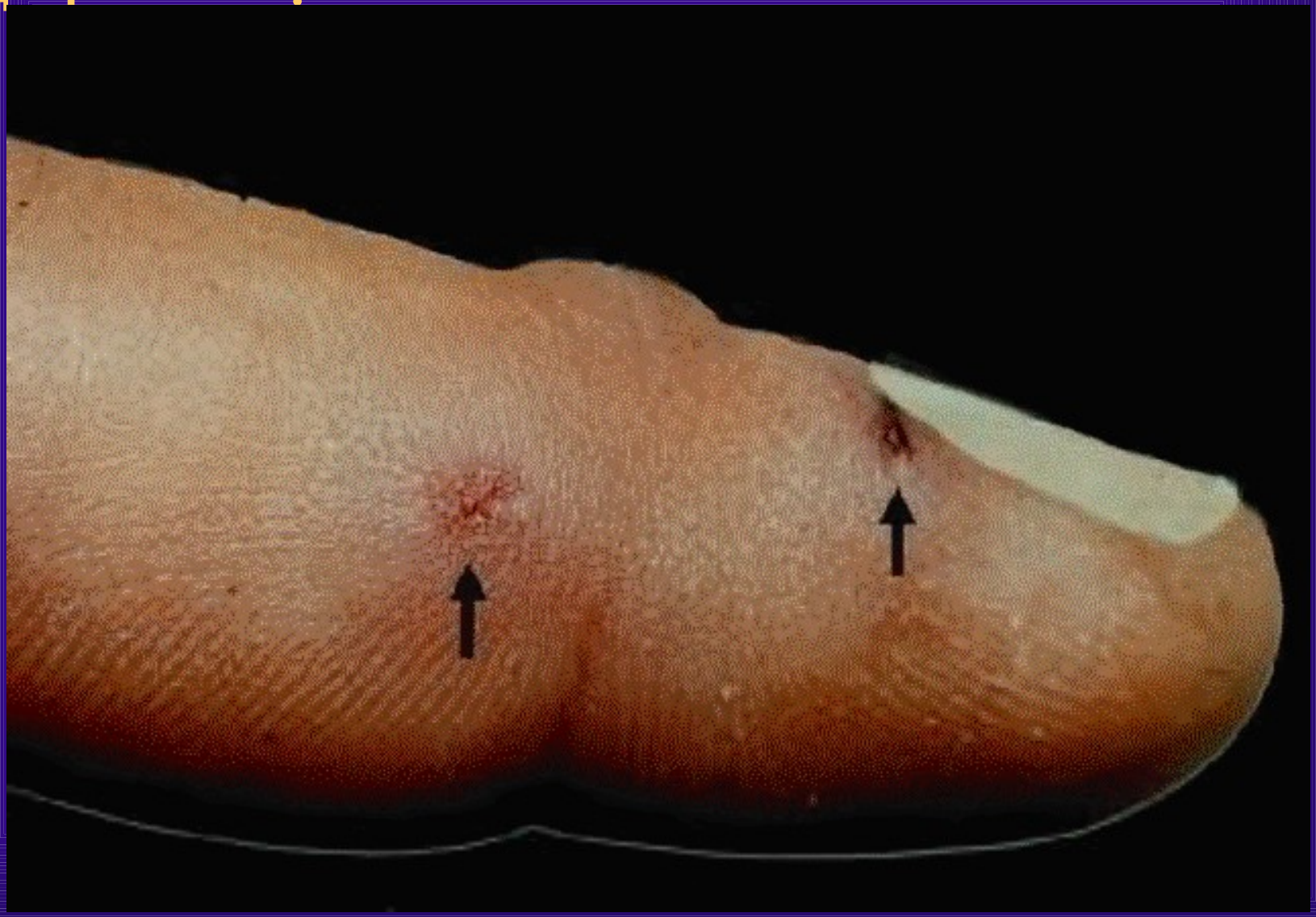
Tularemia "Rabbit Fever"

- **Etiologic Agent:** ***Francisella tularensis***
- **Transmission:** 10-50 organisms
  - Natural: Tick bite, contact with infected mammals/carcasses
  - BW: Aerosol, water, food
- **Incubation:** 1 to 10 days
- **BW Presentation:**
  - Pneumonia (aerosol)
  - Febrile illness (food, water)
- **Fatality rate:** Up to 70% (pneumonia)
- **Treatment:** Streptomycin, tetracycline
- **Vaccine:** Live (investigational)

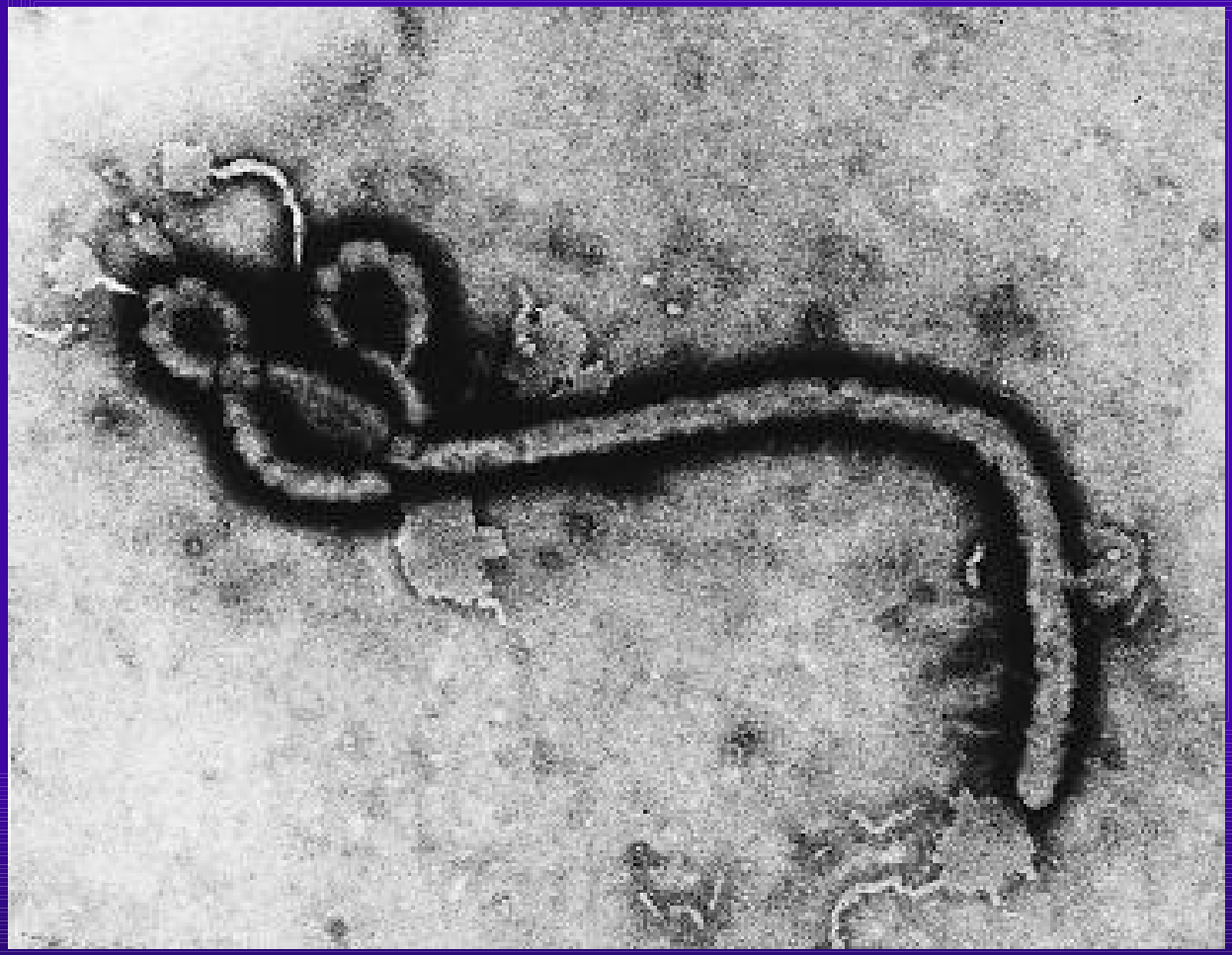
Pathogenesis

- **Infectious dose 10-50 organisms** by aerosol or intradermal route
- Entry through skin, mucosa, lung with development of local lesion and spread to draining lymph node
- High Bacteremia
- Secondary spread to lung and other organs
- Immunity is cell-mediated

Skin lesions of ulceroglandural T



Viral Agents



Viruses as BW Agents

- Efficient production
- Stability (+/-)
- High infectivity rates
- Consistent induction
- Vaccination

Viral Hemorrhagic Fevers

- **Etiologic agent**: YF, RVF, Ebola, Marburg, CCHF
- **Transmission**: 1-10 organisms
  - natural: multiple
  - biological: aerosol or possibly vector
- **Incubation**: 4-21 days
- **BW Presentation**: onset of large numbers fever, myalgia, prostration w/ subsequent microvasculature collapse
- **Fatality rate**: Up to 70%
- **Treatment**: supportive, some Ribavirin, some passive antibody
- **Vaccine**: IND except YF

Poxviruses

- Largest known viruses (200 x 250 nm)
- Double stranded DNA genome
- Codes for enzymes-DNA replication, translation, transcription
- DNA replication and viral assembly occur in cytoplasm

Poxviruses:Human Pathogens

- Variola
- Monkeypox
- Cowpox
- Vaccinia-live vaccine, possible side-effects

Smallpox

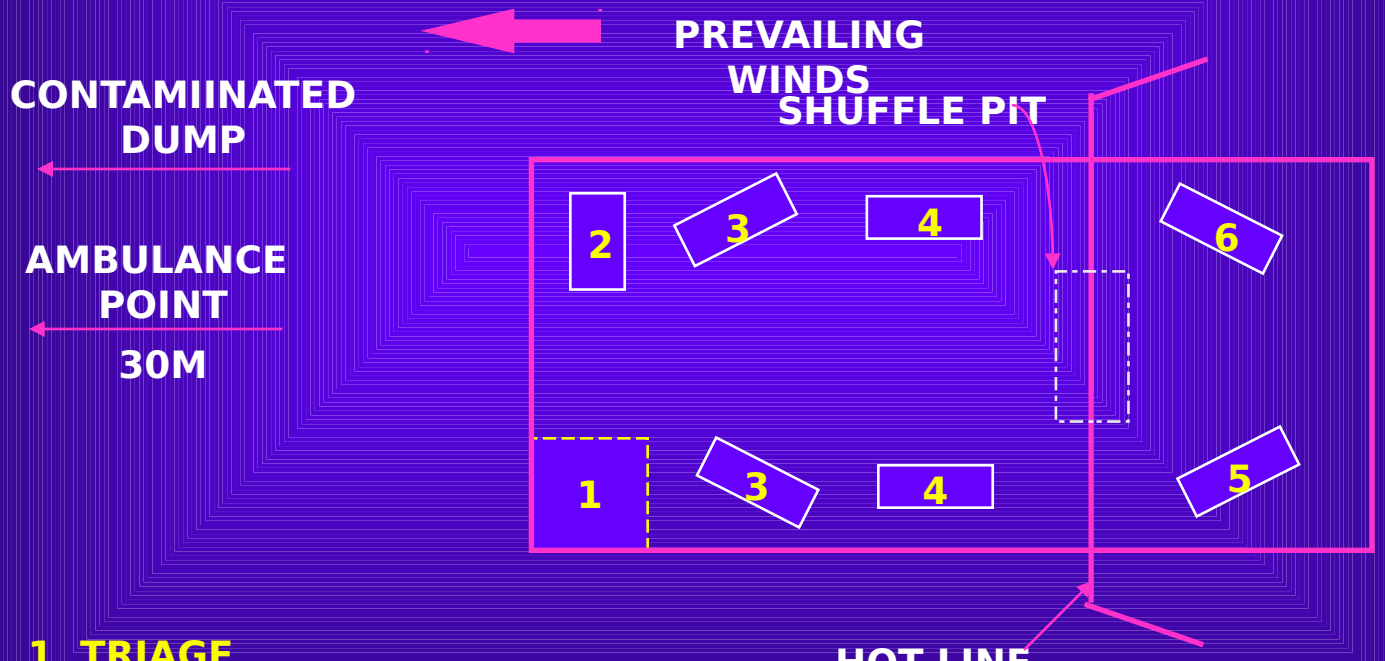
- Important cause of morbidity and mortality in developing world until recent times
- Known in antiquity
- 18th century England:
  - 1/14 to 1/8 of all deaths
  - 1/3 of deaths of young children
  - Case fatality rate 20-40%

a. Third Day of Rash

b. Fifth Day of Rash

c. Seventh Day of Rash

PATIENT DECONTAMINATION



1 TRIAGE
2 EMERGENCY TREATMENT
3 CLOTHING REMOVAL
4 SKIN DECONTAMINATION
5 CLEAN TREATMENT
6 PNT WAITING

Any Questions?